

# SURFACE TREATMENT METHOD FOR RARE EARTH MAGNET

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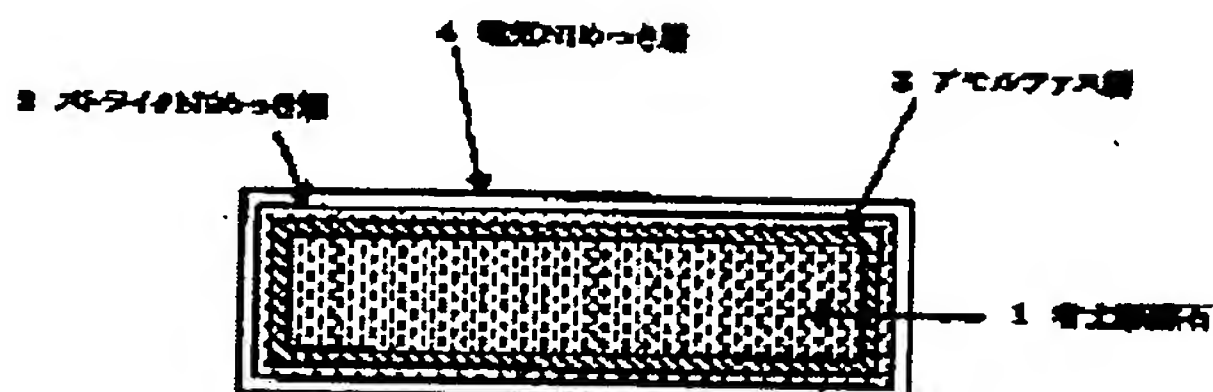
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## Abstract of JP2004002911

PROBLEM TO BE SOLVED: To form a plating film which has tight adhesion with a magnet base material.

SOLUTION: In the surface treatment method for a rare earth magnet 1, the surface of a rare earth magnet composed of rare earth elements consisting essentially of Nd, transition metals consisting essentially of iron, and B is melted, and is thereafter rapidly cooled, and a protective layer is formed on the rapidly cooled layer by a plating method. Further, as the melting method, a laser beam can be used, and the rapidly cooled layer can be composed of an amorphous layer 2, and the protective layer can be composed of a strike Ni plating layer 3 and an electrical Ni plating layer 4.

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**CLAIMS**

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[Claim(s)]

[Claim 1]

The surface treatment approach of the rare earth magnet characterized by quenching in the surface treatment approach of the permanent magnet which consists of the rare earth elements which use Nd as a principal component, a transition element which uses iron as a principal component, and B after fusing the front face of said permanent magnet, and forming a protective layer in the front face of a quenching layer by the galvanizing method.

[Claim 2]

The surface treatment approach of the rare earth magnet according to claim 1 characterized by performing said melting approach using a laser beam.

[Claim 3]

The surface treatment approach of the rare earth magnet according to claim 1 or 2 characterized by for said quenching layer being an amorphous layer and said protective layers being a strike nickel plating layer and electric nickel plating layer.

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**DETAILED DESCRIPTION**

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[Detailed Description of the Invention]

[0001]

[Field of the Invention]

This invention relates to the surface treatment approach of the high energy product rare earth magnet used for the magnetic-head driving gear of an AC servo motor, a linear motor, and the hard disk for data logging.

[0002]

[Description of the Prior Art]

Although the permanent magnet ingredient which consists of the rare earth elements which use Nd as a principal component, a transition element which uses iron as a principal component, and B is used abundantly as strongest magnet with the energy product of the current highest at the motor for industrial use etc., since the rare earth elements which are iron and an activity metal as a component are included, with the moisture in air, rust is produced and magnetic properties tend to fall. For this reason, rust-proofing film, such as plating and paint, is used for the front face, forming.

In it, how to form a protective coat by the galvanizing method is shown in drawing 4. Drawing 4 is the cross section showing the conventional rare earth magnet. nickel strike plating layer 3 by electrolysis is formed in the front face of a rare earth magnet 1, and electric nickel plating layer 4 is formed on it (for example, JP,05-082322,A). In this case, as pretreatment of plating, by the surface treatment method wet [ using a water solution ], adjustment of a magnet base is performed and the plating coat is formed after that.

[0003]

[Problem(s) to be Solved by the Invention]

However, by the above-mentioned conventional approach, the rare earth magnet front face at the time of plating pretreatment changes, as shown in drawing 5. As for the Nd<sub>2</sub>Fe<sub>14</sub>B phase whose 5 is the main phase in magnet material, and 6, a Nd<sub>1</sub>Fe<sub>4</sub>B<sub>4</sub> phase and 7 are Nd rich phases. That is, the activity Nd rich phase 7 dissolves in the electrochemistry target which exists in the boundary of the particle of Nd<sub>2</sub>Fe<sub>14</sub>B phase 5 into processing liquid preferentially. For this reason, there was a problem that the adhesion between the plating coat which the fixing force of the grains of the main phase declines and is formed after that, and a magnet base became low. Therefore, by the motor which pasted up the magnet after plating on the motor core, the nonconformity that a magnet exfoliated in the interface of a plating coat and a magnet base might be produced according to the centrifugal force at the time of the expansion contraction and the high-speed revolution at the time of the heat hardening of adhesives.

Then, the object of this invention is offering the surface treatment approach of a magnet raw material for adhesion with a magnet base to form a good plating coat.

[0004]

[Means for Solving the Problem]

In order to solve the above-mentioned problem, in this invention, it quenches, after fusing the front face of the permanent magnet ingredient which consists of the rare earth elements which use Nd as a principal component, a transition element which uses iron as a principal component, and B, and the plating layer for protecting a magnet base is formed on this melting layer. If melting quenching only of the front face of a rare earth magnet is carried out, since a chemical-resistant good amorphous

layer will generate on a magnet front face and a magnet base will be protected in this amorphous layer, in case it is plating pretreatment, the fixing force of the particle of the main phase does not decline. Moreover, since a plating coat is formed on an amorphous layer, it does not produce lowering of the adhesion force of a plating coat, either.

Although it considers as the approach of carrying out melting quenching of the magnetic front face and there are various approaches, the approach of using a laser beam is most suitable as an approach of fusing only a magnet surface layer, without raising the temperature of a magnet body, since energy can be concentrated on a minute part while being able to process in atmospheric air.

[0005]

[Embodiment of the Invention]

The operation gestalt of this invention is explained based on drawing.

The cross section of the rare earth magnet which produced drawing 1 by the surface treatment approach of this invention, and drawing 2 show the enlarged section mimetic diagram of the surface treatment section. 2 is an amorphous layer and other signs are the same as the former.

In order to fuse the front face of the rare earth magnet 1 which consists of the rare earth elements, iron, and B which use Nd as a principal component, the laser-heating equipment shown in drawing 3 was used. The laser-heating equipment of drawing 3 consists of the laser light source 9, the optical system 10 which converges a laser on a narrow beam and X-Y stage 12 which moves a rare earth magnet to the 2-way of XY, and its controller 13.

After fusing the front face of a rare earth magnet by using the YAG laser of maximum output 100W for the laser light source 9, and changing the passing speed of the X-Y stage 12, a laser output, and the pulse number per for 1 second, it adjusted so that it might quench and an amorphous layer with a thickness of about 15 micrometers could be formed.

It quenched and the amorphous layer was formed, after fusing the front faces of all the 6th page of a magnet. Then, alkaline degreasing, electrolytic degreasing, and acid-washing processing were performed, it was immersed into the plating liquid containing Chlorination nickel and a hydrochloric acid, and strike nickel plating was performed. Electric nickel plating was performed to 20 micrometers of thickness after rinsing in the plating liquid containing a sulfuric acid nickel, Chlorination nickel, and a way acid.

The sample which performed surface etching by the wet method, alkaline degreasing, and activation, and performed strike nickel plating and electric nickel plating on the same conditions as an example like the conventional nickel plating rare earth magnet as an example of a comparison was also produced ( drawing 4 ).

The epoxy adhesive was used for the steel block and both nickel plating rare earth magnet of this example and the example of a comparison was pasted up, respectively. Shear peel strength was investigated for adhesives after heat hardening. Moreover, the blemish which reaches to a magnet base was put into nickel plating film in the phi10mm configuration, and the rod made from phi10mm carbon steel was stuck on this with epoxy system adhesives. After carrying out heat hardening of the adhesives, the magnet was pulled and it fixed to one side of a testing machine, and it has already fixed to one of the two, the rod was pulled apart, and the adhesion reinforcement of a plating coat was investigated.

The result is shown in a table 1. A table 1 is the average which measured the shear peel strength and adhesion reinforcement of the plating film of nickel plating rare earth magnet.

[0006]

[A table 1]

測定品	せん断剥離強度 (kgf/cm <sup>2</sup> )	めっき密着強度 (kgf/cm <sup>2</sup> )
実施例	2 8 5	5 8 0
比較例	1 0 8	3 7 2

[0007]



All exfoliations of the rare earth magnet of this example were produced the interface of adhesives and nickel plating coat, and inside the adhesives layer, and all exfoliations were produced in the magnetic front face and the interface of a strike nickel plating coat about the example of a comparison.

The example of this invention has the adhesion better than a table 1 between a magnet base and nickel plating, and it was able to be made stronger than the mechanical strength of the adhesives itself. For this reason, adhesives were used for Rota of a motor, and even if it rotated at high speed, it did not exfoliate [ installation and ] from the interface of a magnet and a plating coat.

In addition, in this example, as an approach of carrying out melting quenching of the magnet front face, and forming an amorphous layer, although laser was used, even if it puts in a work piece into a vacuum, it applies an electron beam and it fuses a front face, the same effectiveness is acquired. In addition, if it is the approaches of giving the energy which fuses only the front face of a rare earth magnet, such as the approach of fusing a front face using the spark by discharge, the effectiveness of raising the adhesion of a magnet front face and the plating film as well as the example of this invention will be acquired.

Moreover, although electric nickel plating coat was formed in the magnet front face in this example, a plating coat is not limited to the electrolysis plating of nickel, it is the metal which can form a metallic film with electrolysis plating or nonelectrolytic plating from water solutions, such as Cu, and Ag, Au, Cr, and if a resistance to environment is good, the protective effect of the same adhesion as nickel plating and a magnet base will be acquired.

[0008]

[Effect of the Invention]

Since the good plating protective coat of a magnet base and adhesion can be formed according to the surface treatment approach of a rare earth magnet according to claim 1 as stated above, the nonconformity of exfoliating in a magnetic base and the interface of plating according to the centrifugal force at the time of the expansion contraction at the time of the heat hardening after adhesion to a motor core or a high-speed revolution of a motor is not produced. For this reason, a reliable AC servo motor and a reliable linear motor can be manufactured. Moreover, since melting quenching processing on the front face of a magnet for forming the good plating film of adhesion can be performed in atmospheric air according to the surface treatment approach of a rare earth magnet according to claim 2, a rare earth magnet with a plating coat can be manufactured cheaply.

[Brief Description of the Drawings]

[Drawing 1] The mimetic diagram of the rare earth magnet cross section produced by the surface treatment approach of this invention.

[Drawing 2] The enlarged section mimetic diagram of the surface treatment section in drawing 1.

[Drawing 3] The block diagram of the laser-heating equipment used for the surface treatment of this invention.

[Drawing 4] The mimetic diagram of the rare earth magnet cross section produced by the conventional surface treatment approach.

[Drawing 5] The explanatory view explaining the mechanism of poor adhesion of the conventional rare earth magnet.

[Description of Notations]

- 1 Rare Earth Magnet
- 2 Amorphous Layer
- 3 Strike Nickel Plating Layer
- 4 Electric Nickel Plating Layer
- 5 Nd<sub>2</sub>Fe<sub>14</sub>B Phase
- 6 Nd<sub>1</sub>Fe<sub>4</sub>B<sub>4</sub> Phase
- 7 Nd Rich Phase
- 8 Power Source for Laser
- 9 Laser Light Source
- 10 Optical System
- 11 Laser Beam
- 12 X-Y Stage

### 13 X-Y Stage Controller

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**DESCRIPTION OF DRAWINGS**

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[Brief Description of the Drawings]

[Drawing 1] The mimetic diagram of the rare earth magnet cross section produced by the surface treatment approach of this invention.

[Drawing 2] The enlarged section mimetic diagram of the surface treatment section in drawing 1.

[Drawing 3] The block diagram of the laser-heating equipment used for the surface treatment of this invention.

[Drawing 4] The mimetic diagram of the rare earth magnet cross section produced by the conventional surface treatment approach.

[Drawing 5] The explanatory view explaining the mechanism of poor adhesion of the conventional rare earth magnet.

[Description of Notations]

- 1 Rare Earth Magnet
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- 4 Electric Nickel Plating Layer
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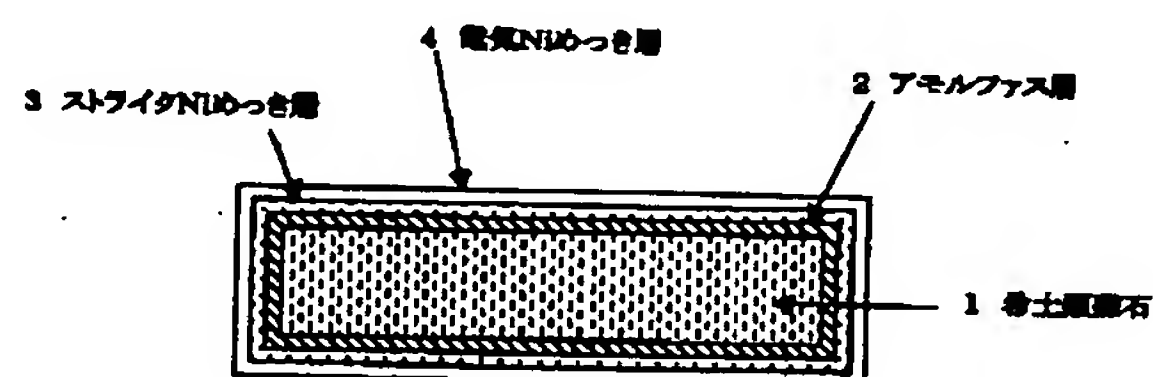
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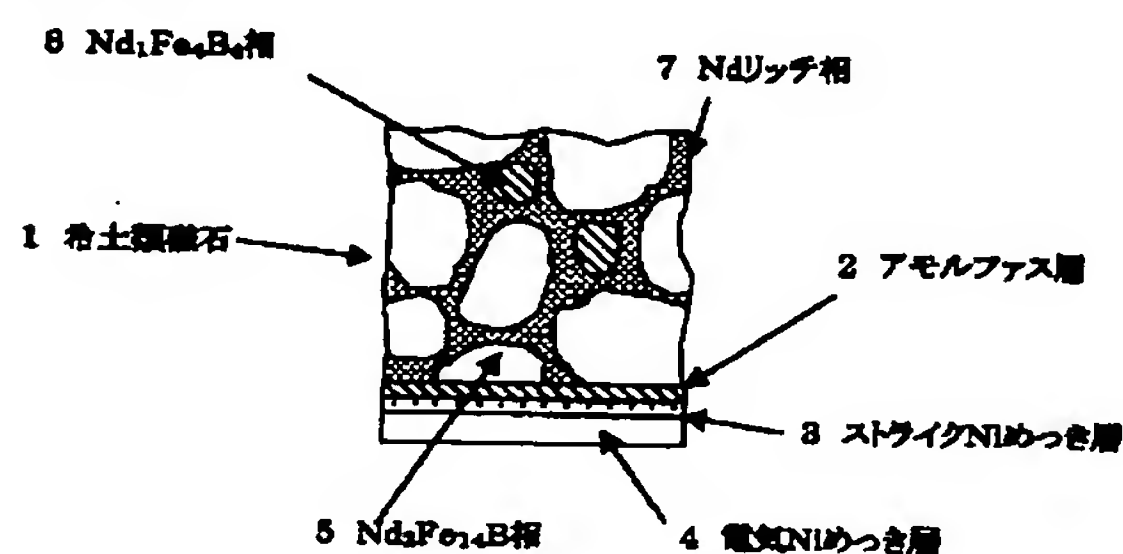
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## DRAWINGS

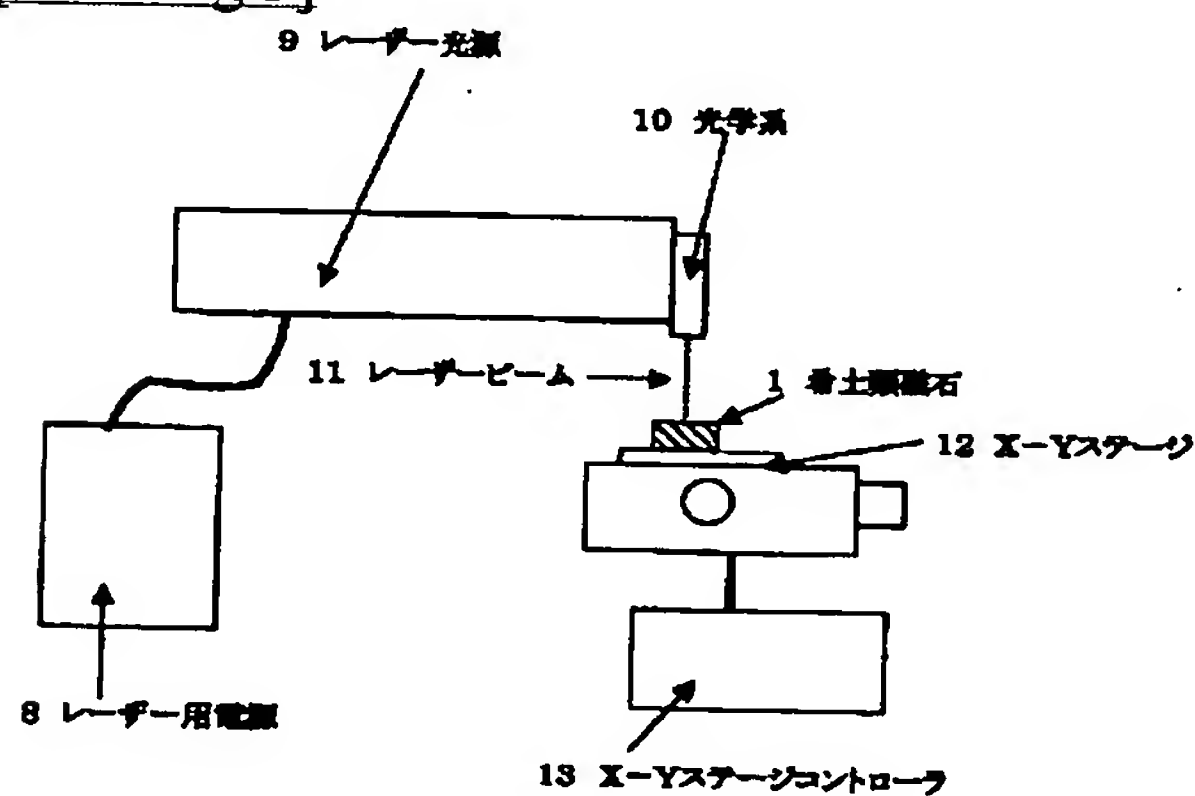
[Drawing 1]



[Drawing 2]

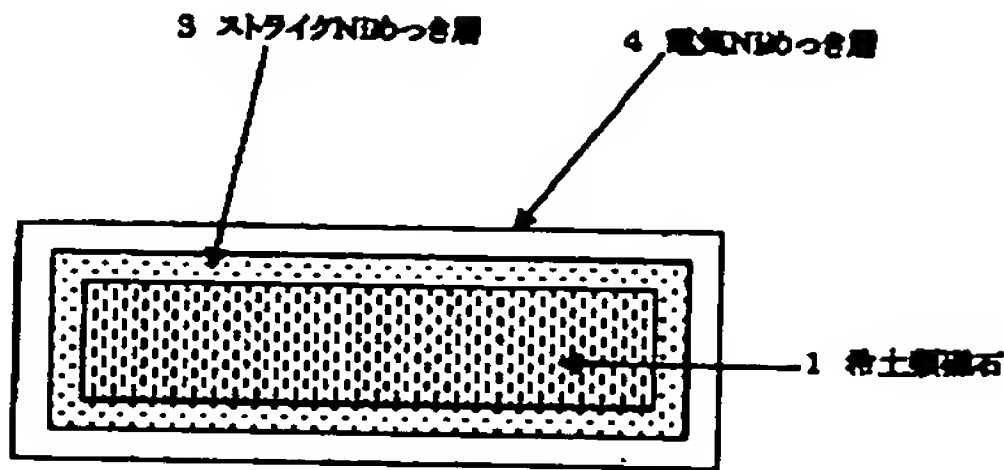


[Drawing 3]

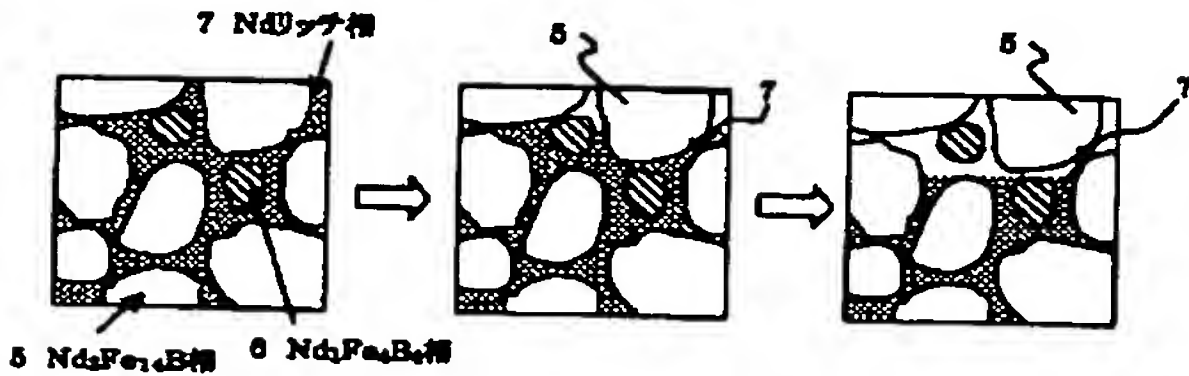


[Drawing 4]





[Drawing 5]



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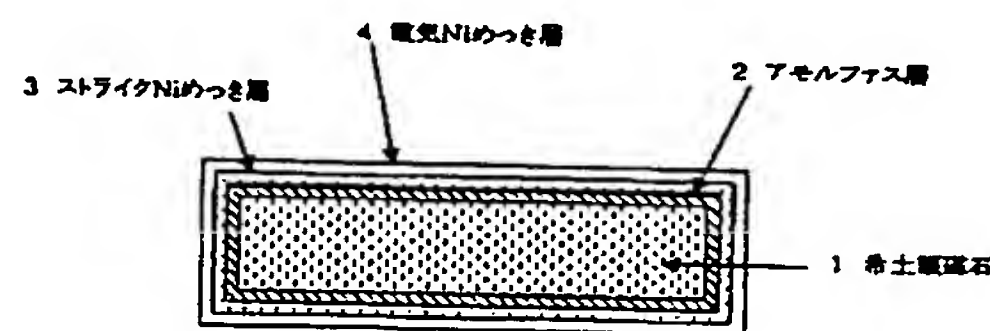
(54) 【発明の名称】 希土類磁石の表面処理方法

(57) 【要約】

【課題】 磁石素地と密着性の良いめっき皮膜を形成することである。

【解決手段】 本発明の希土類磁石1の表面処理方法は、Ndを主成分とする希土類元素、鉄を主成分とする遷移元素およびBからなり、希土類磁石の表面を熔融した後急冷し、急冷層の表面にめっき法によって保護層を形成したものである。また、熔融方法としてレーザービームを用いて行ってもよいし、急冷層をアモルファス層2とし、保護層をストライクNiめっき層3と電気Niめっき層4としてもよい。

【選択図】 図1



FP05-0116-
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## 【特許請求の範囲】

## 【請求項 1】

Ndを主成分とする希土類元素、鉄を主成分とする遷移元素およびBからなる永久磁石の表面処理方法において、前記永久磁石の表面を熔融した後急冷し、急冷層の表面にめっき法によって保護層を形成することを特徴とする希土類磁石の表面処理方法。

## 【請求項 2】

前記熔融方法をレーザービームを用いて行うことを特徴とする請求項 1 記載の希土類磁石の表面処理方法。

## 【請求項 3】

前記急冷層がアモルファス層であり、前記保護層がストライクNiめっき層と電気Niめっき層であることを特徴とする請求項 1 または 2 記載の希土類磁石の表面処理方法。

## 【発明の詳細な説明】

## 【0001】

## 【発明の属する技術分野】

本発明は、ACサーボモータやリニアモータ、データ記録用ハードディスクの磁気ヘッド駆動装置に利用される高エネルギー積希土類磁石の表面処理方法に関するものである。

## 【0002】

## 【従来の技術】

Ndを主成分とする希土類元素、鉄を主成分とする遷移元素およびBからなる永久磁石材料は、現在最高のエネルギー積を持つ最強の磁石として、産業用モータなどに多用されているが、成分として鉄や活性な金属である希土類元素を含むため、空気中の水分によって錆を生じて磁気特性が低下しやすい。このため、めっきや塗装などの防錆膜を表面に形成して使用されている。

その中で、めっき法によって保護膜を形成する方法を図4に示す。図4は、従来の希土類磁石を示す断面模式図である。希土類磁石1の表面に電解によるNiストライクめっき層3を形成し、その上に電気Niめっき層4を形成している（例えば特開平05-082322）。この場合、めっきの前処理として、水溶液を使った湿式の表面処理法によって磁石素地の調整が行われ、その後めっき皮膜が形成されている。

## 【0003】

## 【発明が解決しようとする課題】

しかしながら、上記従来の方法では、めっき前処理時の希土類磁石表面は、図5に示すように変化する。5は磁石材中の主相であるNd<sub>2</sub>Fe<sub>14</sub>B相、6はNd<sub>1</sub>Fe<sub>4</sub>B<sub>4</sub>相、7はNdリッチ相である。すなわち、Nd<sub>2</sub>Fe<sub>14</sub>B相5の粒子の境界に存在する電気化学的に活性なNdリッチ相7が優先的に処理液中へ溶解する。このため、主相の粒同士の固着力が低下し、その後形成されるめっき皮膜と磁石素地間の密着性が低くなるという問題があった。したがって、めっき後の磁石をモータコアへ接着したモータでは、接着剤の加熱硬化時の膨張収縮や高速回転時の遠心力によって、磁石がめっき皮膜と磁石素地の界面で剥離するといった不具合を生じることがあった。

そこで、本発明の目的は、磁石素地との密着性が良いめっき皮膜を形成するための磁石素材の表面処理方法を提供することである。

## 【0004】

## 【課題を解決するための手段】

上記問題を解決するため本発明では、Ndを主成分とする希土類元素、鉄を主成分とする遷移元素およびBからなる永久磁石材料の表面を熔融した後急冷し、この熔融層の上に磁石素地を保護するためのめっき層を形成するものである。希土類磁石の表面のみを熔融急冷すると、磁石表面に耐薬品性の良いアモルファス層が生成し、このアモルファス層で磁石素地が保護されるため、めっき前処理の際に、主相の粒子の固着力が低下することがない。また、めっき皮膜はアモルファス層の上に形成されるため、めっき皮膜の密着力の低下も生じることがない。

磁石の表面を熔融急冷する方法として種々の方法があるが、レーザービームを使用する方

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法は、大気中で処理が可能であるとともに、エネルギーを微小部分に集中できるので、磁石本体の温度を上げることなく、磁石表面層のみを熔融する方法として最も適している。

【0005】

【発明の実施の形態】

本発明の実施形態を図に基づいて説明する。

図1は本発明の表面処理方法によって作製した希土類磁石の断面模式図、図2は表面処理部の拡大断面模式図を示す。2はアモルファス層であり、他の符号は従来と同じである。Ndを主成分とする希土類元素、鉄およびBからなる希土類磁石1の表面を熔融するために、図3に示すレーザー加熱装置を使用した。図3のレーザー加熱装置は、レーザー光源9とレーザーを細いビームに収束する光学系10、希土類磁石をXYの2方向に移動させるX-Yステージ12とそのコントローラ13から構成されている。

レーザー光源9に最大出力100WのYAGレーザーを使用し、X-Yステージ12の移動速度とレーザー出力および1秒間当たりのパルス数を変化させることにより、希土類磁石の表面を熔融した後、急冷して厚み約15 $\mu$ mのアモルファス層が形成できるように調整した。

磁石の6面すべての表面を熔融した後、急冷してアモルファス層を形成した。その後、アルカリ脱脂、電解脱脂、酸洗処理を行い、塩化Niと塩酸を含むめっき液中に浸漬して、ストライクNiめっきを行った。水洗後、硫酸Ni、塩化Ni、およびほう酸を含むめっき液中で膜厚20 $\mu$ mまで電気Niめっきを行った。

比較例として、従来のNiめっき希土類磁石と同様に、湿式法による表面エッチングとアルカリ脱脂、活性化処理を行い、実施例と同じ条件でストライクNiめっきと電気Niめっきを行ったサンプルも作製した(図4)。

本実施例および比較例の両Niめっき希土類磁石をそれぞれ鋼製のブロックにエポキシ接着剤を用いて接着した。接着剤を加熱硬化後、せん断剥離強度を調べた。また、 $\phi$ 10mmの形状で、Niめっき膜に磁石素地まで達する傷を入れ、これに $\phi$ 10mmの炭素鋼製のロッドをエポキシ系接着剤で貼り付けた。接着剤を加熱硬化した後、磁石を引っ張り試験機の片側に固定し、ロッドをもう片方に固定して引き離し、めっき皮膜の密着強度を調べた。

その結果を表1に示す。表1はNiめっき希土類磁石のめっき膜のせん断剥離強度と密着強度を測定した平均値である。

【0006】

【表1】

測定品	せん断剥離強度 (kgf/cm <sup>2</sup> )	めっき密着強度 (kgf/cm <sup>2</sup> )
実施例	285	580
比較例	108	372

【0007】

本実施例の希土類磁石の剥離は、すべて接着剤とNiめっき皮膜の界面および接着剤層の内部で生じ、比較例については、剥離はすべて磁石の表面とストライクNiめっき皮膜の界面で生じた。

表1より、本発明の実施例は磁石素地とNiめっき間の密着性が良好であり、接着剤自体の機械強度よりも強くすることができた。このため、モータのロータに接着剤を用いて取り付け、高速度で回転しても磁石とめっき皮膜の界面から剥離することがなかった。

なお、本実施例では、磁石表面を熔融急冷してアモルファス層を形成する方法として、レーザーを使用した。真空中にワークを入れ、電子ビームを当てて表面を熔融しても同じ効果が得られる。その他、放電によるスパークを用いて表面を熔融する方法など、希土類磁石の表面のみを熔融するエネルギーを与えることが可能な方法であれば、本発明の実施例と同様、磁石表面とめっき膜の密着性を向上させる効果が得られる。

また、本実施例では磁石表面に電気Niめっき皮膜を形成したが、めっき皮膜はNiの電解めっきに限定されるものではなく、CuやAg, Au, Crなど水溶液から電解めっきあるいは無電解めっきで金属皮膜を形成できる金属であって、耐環境性の良いものであれば、Niめっきと同様な密着性と磁石素地の保護効果が得られる。

【0008】

【発明の効果】

以上述べたように、請求項1記載の希土類磁石の表面処理方法によれば、磁石素地と密着性の良いめっき保護膜を形成できるので、モータコアへの接着後の加熱硬化時の膨張収縮やモータの高速回転時の遠心力によって、磁石の素地とめっきの界面で剥離するといった不具合を生じない。このため、信頼性の高いACサーボモータやリニアモータを製造することができる。また、請求項2記載の希土類磁石の表面処理方法によれば、密着性の良いめっき膜を形成するための磁石表面の溶融急冷処理を大気中で行うことができるので、めっき皮膜付き希土類磁石の製造を安価に行うことができる。

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【図面の簡単な説明】

【図1】本発明の表面処理方法によって作製した希土類磁石断面の模式図。

【図2】図1における表面処理部の拡大断面模式図。

【図3】本発明の表面処理に用いたレーザー加熱装置の構成図。

【図4】従来の表面処理方法によって作製した希土類磁石断面の模式図。

【図5】従来の希土類磁石の密着不良のメカニズムを説明する説明図。

【符号の説明】

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1 希土類磁石

2 アモルファス層

3 ストライクNiめっき層

4 電気Niめっき層

5  $Nd_2Fe_{14}B$ 相

6  $Nd_1Fe_4B_4$ 相

7 Ndリッチ相

8 レーザー用電源

9 レーザー光源

10 光学系

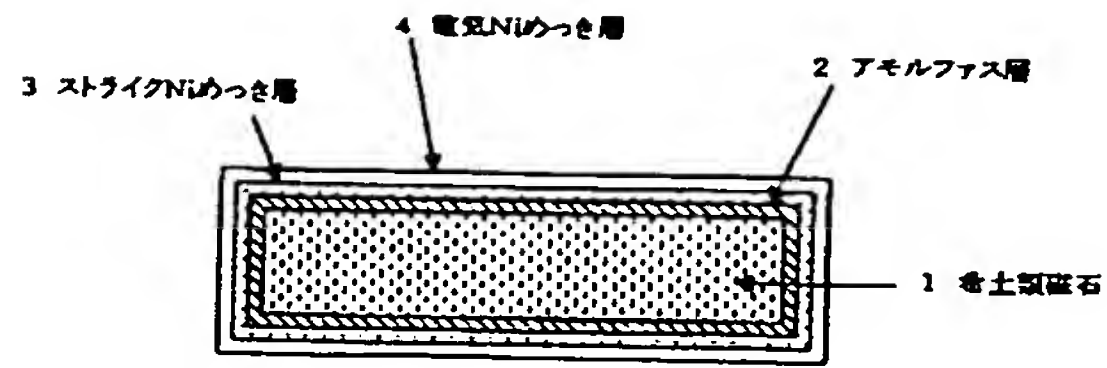
30

11 レーザービーム

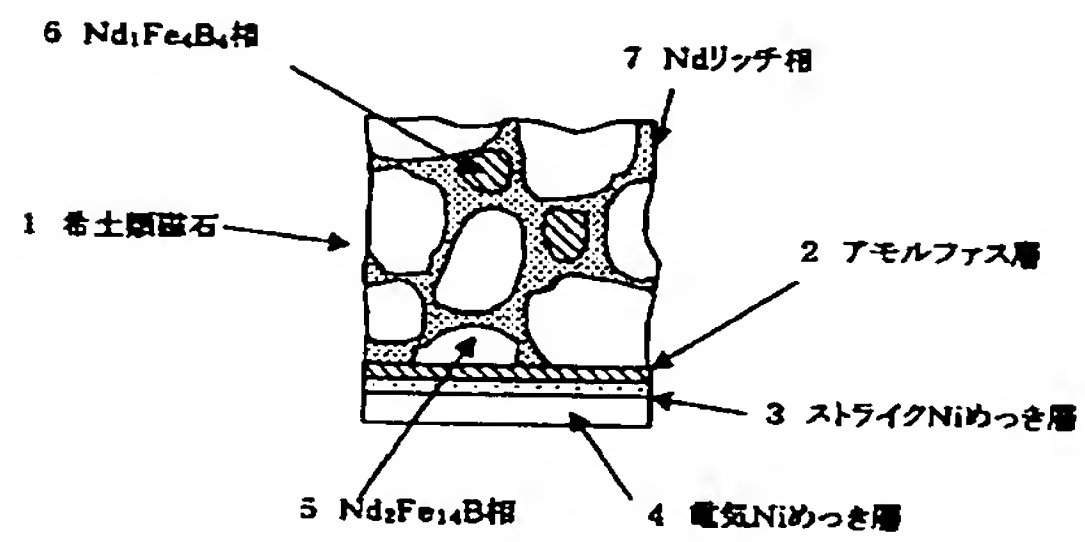
12 X-Yステージ

13 X-Yステージコントローラ

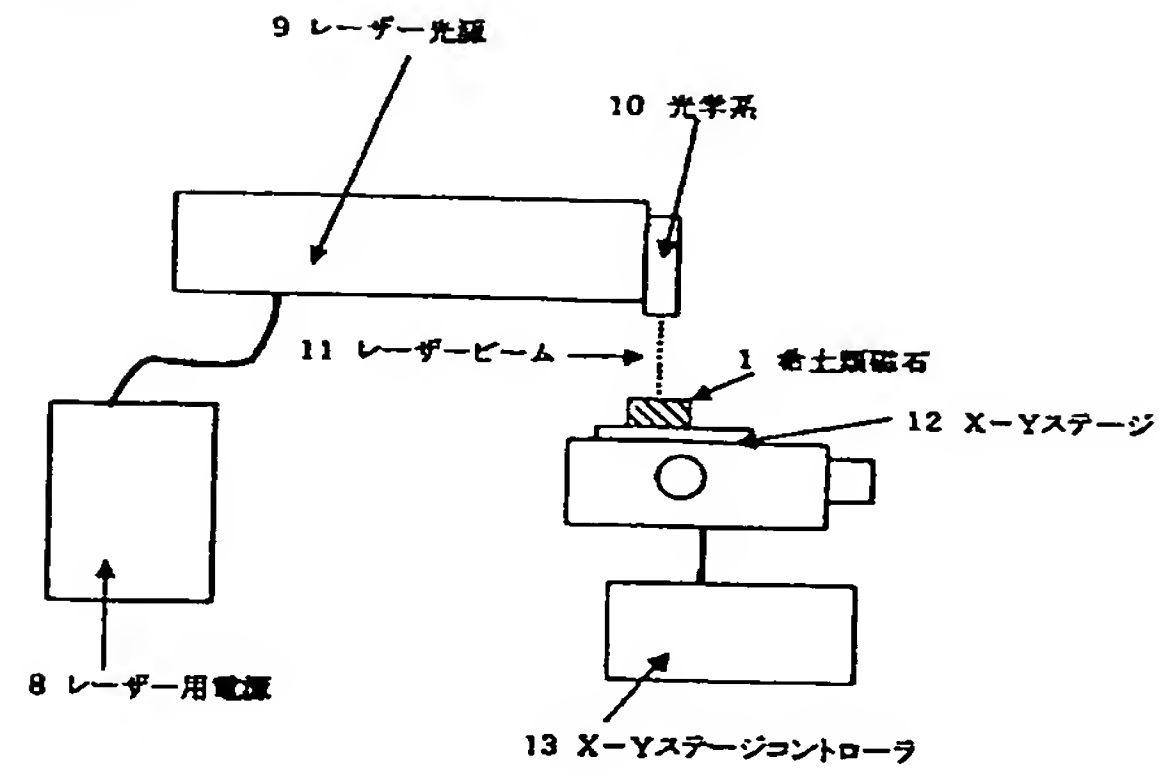
【図 1】



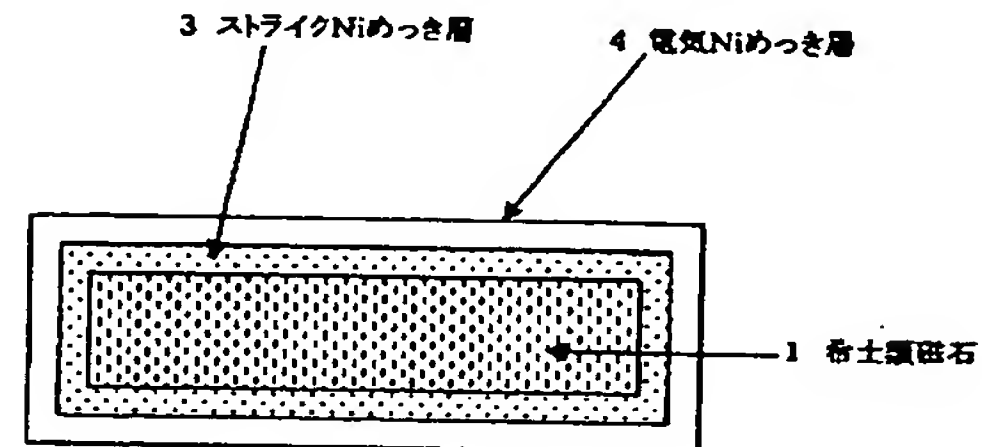
【図 2】



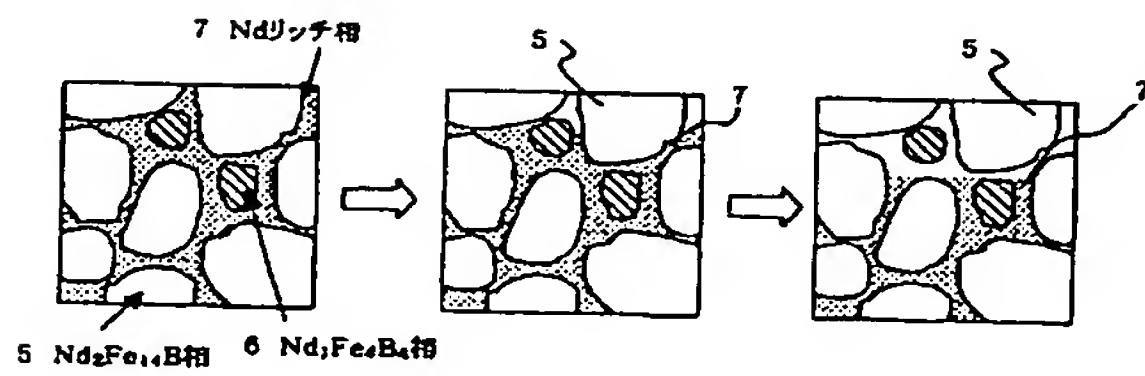
【図 3】



【図 4】



【図 5】





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